How do streams with different riparian land uses vary in their response to precipitation events as measured by phosphorus levels?

Denir Djozic, Andrew Pike, Grace Yasewicz, and Kara Lenorovitz Colchester High School, Colchester, VT

Introduction:

In this investigation, the relationship between land use and phosphorus levels in the water was analyzed in order to understand its response to storm events. This helps illustrate how the water quality of Lake Champlain could be affected as a warmer climate creates larger storms events, along with the changing land use in the surrounding areas.

Phosphorus is an essential nutrient in the growth of plants and animals. Therefore, it is essential to plants and other organisms living in Lake Champlain and the surrounding watersheds. The problem occurs when an excess of phosphorus ends up in the water, disturbing the existing nutrient balance. Phosphorus stimulates growth, meaning an overabundance can cause plants and algae in the lake to grow excessively. The ultimate decomposition of these plants creates an anoxic environment for other organisms. As a result, the normal ecosystem is dramatically altered.

Phosphorus reaches streams in different ways. Land use can affect the amount of phosphorus in the soil and the amount of water draining into streams after storm events. Phosphorus comes from point (20%) and non-point source pollution (80%). Point sources are localized and easily identifiable. Non-point sources contribute to the rest of the excess phosphorus and include runoff from farm fields, forests, and residential lawns fertilized with high phosphorus fertilizers. Urban areas have paved and impervious surfaces resulting in storm events rushing pollutants (excess phosphorus) into storm drains leading directly to streams. This leads to an increase in both water and phosphorus levels.

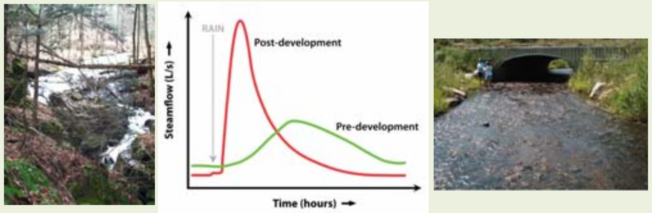


Figure 1 : Comparison of appearance and storm response of streams located in forested and urban catchments. Storm discharge graph accessed on 3.17.2013 from: http://www.learnnc.org/lp/editions/mudcreek/6394.

Methods:

The stream gage data selected for analysis in this investigation was in response to a major storm on September 5, 2012 it was collected between September 1, 2012 and September 10, 2012. This major rainfall was classified as a storm using USGS hydrographs of each stream site as a reference. For sites that were not directly monitored by a USGS stream gauge, a site within reasonable distance was chosen as a representation. Significant peaks in water level depicted by these graphs were considered major storms. The storm of September 5th had an impact on all studied sites.

Phosphorus data was collected by both St. Michael's college undergraduates and various high school teams between July 2012 and November 2012. This created a discrepancy in the collection method of stream phosphorus levels based on the sampling techniques of the St. Michael's students versus the high school students. Phosphorus data in streams monitored by St. Michael's was collected by an autosampler that was activated by elevated stream levels during or after a large storm. High school teams used grab sampling techniques to collect water samples bi-weekly indicating total phosphorus levels in the stream.

Soil phosphorus data was collected by high school teams once during the July to November sampling period. Three sets of soil core samples were taken along three transects at the stream site. Transects ran from one meter away from the stream to the very edge of the riparian zone.

Individual streams were categorized by land use based on what percentage of the catchment was agricultural, forested, and urban. Land use per stream was decided by which type of land occupied the majority of the watershed.

Hypothesis:

If there is a large storm event then streams located in catchments with a higher percentage of forest will show lower stream phosphorus levels, lower soil phosphorus levels, and they will show a more gradual change in water level during and after a storm event.

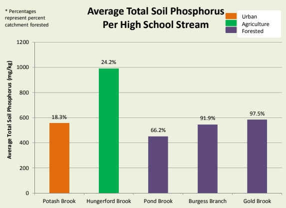


Figure 6: This graph illustrates the average total soil phosphorus of each stream categorized by land use.

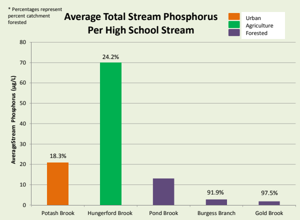


Figure 5: This graph illustrates the average stream phosphorus levels of streams categorized by land use.

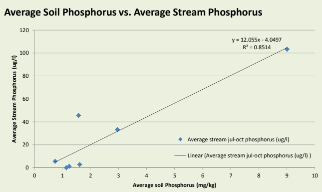


Figure 4 : This graph shows that the more phosphorus there is in the soil surrounding a stream the more phosphorus there will be in the stream.

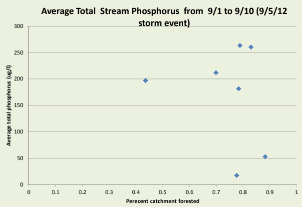


Figure 3: This shows the lack of relationship between percent forested catchment and post-storm average total stream phosphorus.

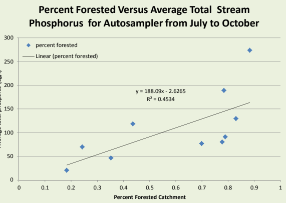
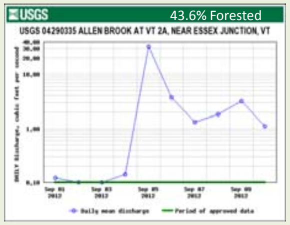
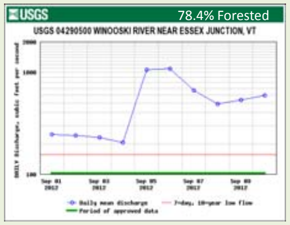


Figure 2 (left): This shows the relationship suggested by the autosampler data between percent forested catchment and average total stream phosphorus.





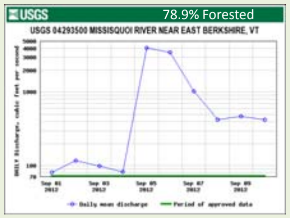


Figure 7: This figure compares hydrographs for more and less forested areas . The Missisquoi sites compare an upstream and downstream location on the same river. While Allen Brook and the Winooski River compare sites on different streams that are within close proximity to each other.

Results:

The autosampler data indicates a stream in a more forested area has more total stream phosphorus than a less forested area, but this is opposite to what soil phosphorus suggests (Fig. 2). This is likely because the autosampler only activates during storm events when the total phosphorus levels are already elevated. Each stream's response to the September 5th storm event shows autosampler data with little correlation between the percent catchment forested and total phosphorus of the stream (Fig 3). Streams in catchments with a similar percent forested had varying responses to the storm event, in regards to the total phosphorus of the streams.

Biweekly grab sampling techniques show an expected trend between the total phosphorus levels of streams and their percent forested catchment (Fig. 4). This data showed there were lower levels of total phosphorus at streams with a higher percentage of forested catchment.

Average total stream and soil phosphorus decreases the more forested an area is (Fig. 5). This trend does not hold true with Hungerford Brook in relation to Potash Brook. This is because Hungerford Brook is predominantly agricultural, meaning there are more non-point sources, such as fertilizers that run off from fields. Stream phosphorus levels also show an inverse relationship with portion of the catchment that is forested

The hydrographs (Fig. 7) of Missisquoi River (78.9% and 69.9% forested catchment) show that the water level of a more forested part of the river changes more slowly than that of a less forested part. Water will run off of a less forested area more quickly because of the possibility of more paved areas, which does not absorb water, and fewer roots, which help the ground hold water. These hydrographs were created using data gathered at different points on the same river, so they will experience similar trends in water levels.

The hydrographs (Fig.7) of Allen Brook and Winooski River are ideal because they are geographically close to each other, but not connected. The stream level of Allen Brook (43.6% forested catchment) peaks and drops much more rapidly, than the Winooski River (78.4% forested catchment). These rivers are very close to each other geographically, meaning they likely experienced a very similar storm event. However, this instance may not be the best example because the rivers are very different in relation to size.

Conclusion:

With climate change, it is expected there will be larger and more frequent storm events. Our data suggests with the large storm events, increased levels of phosphorus will be found in streams along with higher water levels. This effect will be exaggerated in streams not located in predominately forested catchment areas. In order to combat these effects, more developed areas could be reforested. Reforestation efforts have the potential to decrease soil phosphorus levels due to an increase in the number of organisms utilizing phosphorus in the ecosystem. Along with the control of phosphorus levels, reforestation may help to reduce the amount of water that runs off of an area. This could protect the region from events such as flash flooding.

This study could be improved by regularity in the timing and methodology of sampling. Data would be strengthened if the streams had been monitored for phosphorus during both base flow and storm events. This holds true with stream gage data, especially at the autosampler sites. A larger range of impacted sites with varying land use would have allowed for better conclusions to be drawn along with a more consistent collection of soil data at all sites. Additionally, analyzing a larger number of storms would have allowed for more in depth conclusions.

Bibliography:

Inquiry-based Exploration of Human Impacts on Stream Ecosystems: The Mud Creek Case Study. Publication. Learn NC, n.d. Web. 17 Mar. 2013. <http://www.learnnc.org/lp/editions/mudcreek/6394>.

"Lake Champlain Basin Program: Phosphorus Pollution." *Lake Champlain Basin Program*. LCBP, n.d. Web. Feb. 2013. <http://www.lcbp.org/phospsum.htm>.

Reference Manual For High School Teams 2012-2013. Rep. Colchester: Vermont EPSCoR RACC/Saint Michael's College, 2012. Print.

"USGS Current Water Data for Vermont." *USGS: Science For A Changing World*. U.S. Geological Survey, 18 Mar. 2013. Web. 18 Mar. 2013. <http://waterdata.usgs.gov/vt/nwis/rt>.

Funding provided by NSF Grant EPS-1101317